

**ULTRA-HIGH-PERFORMANCE CONCRETE (UHPC).  
(REV 5-9-22)**

The following new Section is added after Section 347.

**SECTION 349  
ULTRA HIGH PERFORMANCE CONCRETE**

**349-1 Description.**

Use ultra-high-performance concrete (UHPC) composed of an optimized gradation of granular constituents, cementitious materials, and reinforcing fibers with a water-to-cementitious materials ratio of less than 0.25. Use only materials listed on the Department's Innovative Product List (IPL).

Prior to casting UHPC field connection joints, construct a mockup of a typical UHPC joint to demonstrate the casting process meets Contract Document requirements.

**349-2 Materials.**

**349-2.1 General:** Meet the following requirements:

Prepackaged Ultra-High-Performance Concrete (UHPC)\*.....Section 927  
Potable Water.....Section 923

\*Use products listed on the Department's IPL.

**349-3 Onsite Supervision of Ultra-High-Performance Concrete (UHPC) Production.**

**349-3.1 General:** Ensure a qualified onsite supervisor and a technical field representative from the manufacturer is on-site during all UHPC production and work activities; including mixing, batching, placement, and curing.

**349-3.2 On-Site Supervisor:** On-site supervisors must meet one of the following requirements.

1. Submit an UHPC manufacturer's certification, indicating that the on-site supervisor has successfully completed the manufacturer's training program.
2. The UHPC bridge closure joints work experience on at least one long bridge (bridges having a length greater than 100 feet) or two short bridges (bridges having a length less than or equal to 100 feet). Submit a list of projects where the work included UHPC production and work activities. For each bridge listed, provide a brief description of each, dates of completion of work, the project owner's name, and the name, title, and current contact information of a project owner representative.

**349-3.3 Manufacturer's Technical Representative:** Arrange for a technical field representative of the UHPC manufacturer to be onsite during mixing, batching, placement, and curing activities of UHPC for bridge construction.

**349-4 Construction Work Plan.**

Submit a detailed work plan to the Engineer for review and approval prior to UHPC pre-pour meeting. As a minimum, include the following items in the work plan:

1. Quality Control Plan (QCP) in accordance with Section 105.
2. Submit the selected IPL product at least 60 days prior to the first anticipated UHPC placement.

3. Project specific storage requirements of UHPC materials ingredients per manufacturer's recommendation.
4. Bridge Plans with dimensions showing connection joints, suggested sequence of UHPC placement, and project schedule requirements.
5. Proposed forming materials and procedure for maintaining watertight joints.
6. Top forms for deck-level connections are prepared and adequate hold downs are available for the top forms.
7. Top form for deck -level connections are set at a minimum of ¼ inch above the top of the deck to allow for all overfilling in accordance with the project Plans.
8. Details of all equipment to be used to batch and place UHPC materials.
9. Schedule and duration of traffic control measures required for completion of the work.
10. Method to attain 1/8 inch to 3/16-inch average amplitude of the exposed aggregate finish for all precast concrete surfaces in contact with UHPC. The use of paste retarders is required to provide the required aggregate finish of precast concrete surfaces in contact with UHPC surfaces.
11. Surface preparation plan of existing concrete surfaces and pre-wetting of the existing concrete interface to a saturated surface-dry (SSD) condition prior to placement of UHPC.
12. Detailed plan and procedure for UHPC joint mockup.
13. Include provisions for acceptable ambient temperature, batch temperatures, ambient relative humidity, batch consistency, and batch times.
14. The mixing, batching, delivery, placement, finishing, and curing procedure of UHPC.
15. The procedure for casting of a demonstration mockup to show the ability to properly cast UHPC components.
16. Proposed schedule and procedure for watertight integrity testing of completed UHPC bridge deck joints.
17. Pre-pour meeting agenda, including manufacturer's recommended topics.

### **349-5 Presence of UHPC Manufacturer Representative.**

Arrange for a representative of the UHPC manufacturer to attend during the pre-pour meeting, the casting of the mockup, and the onsite UHPC placement of bridge construction, as described in 349-3.3.

### **349-6 UHPC Pre-Pour Meeting.**

Conduct a pre-pour meeting prior to the UHPC mockup demonstration.

### **349-7 UHPC Joint Mockup.**

**349-7.1 General:** Construct an UHPC joint mockup in accordance with the design Plans, approved shop drawings, pre-pour meeting discussions, and as recommended by the UHPC manufacturer.

Notify the State Materials Office (SMO) for witnessing, reviewing, and evaluating of the UHPC joint mockup construction operations, at least seven calendar days prior casting of the mockup.

Cast a mockup at least 30 calendar days prior to placement of UHPC at the jobsite or offsite that is full-scale representation of the proposed joint and replicate the form pressure

created by the liquid. Ensure that the mockup replicates the interface between the UHPC and precast concrete panel, roughened to an exposed aggregate finish. The use of paste retarders is required to provide the exposed aggregate finish of precast concrete surface in contact with UHPC surfaces. Following placement and sufficient curing of the UHPC, cut the hardened mockup transversely at two locations to allow for visual inspection of the joint interface and material bond. Make the completed joint mockup cut sections available for review.

The Engineer with input from the SMO or their designated DMRO representative may approve the mockup.

The Engineer's approval of field casting of the UHPC is dependent on successful demonstration of the mockup.

**349-7.2 Mix Workability:** Perform flow loss tests during joint mockup casting to determine the duration that the UHPC will remain workable. Perform the flow tests in accordance with the test method described in Table 349-1 while the ambient temperature is not greater than 90°F and concrete temperature is maintained between 60°F and 85°F.

Perform the following workability procedure during the casting of UHPC joint mockup:

1. Take initial samples prior to the start of the discharge of UHPC and perform the flow tests. Record the time of sampling and initial flow value. Measure the UHPC and ambient temperatures.
2. Continue sampling at 10-minute intervals and determine the flow of each sample, until flow measure is below 4 inches.
3. Plot the flow versus time for the duration of the test. From the plot of flow-time curve, determine the flow time at 8 inches, which is considered the mixture cutoff time.
4. For the production concrete, complete the placement of UHPC in less than or equal to cutoff time.

**349-7.3 Time of Setting:** Perform the Time of Setting test of UHPC in accordance with test method described in Table 349-1.

### **349-8 Construction Methods and Requirements.**

1. Perform forming, batching, placing, and curing in accordance with approved construction work plan.
2. Do not remove formwork until the UHPC achieves a minimum compressive strength of 10,000 psi.
3. Provide the required number of portable high shear batching units, including standby equipment and parts, for mixing of the UHPC in accordance with the manufacturer's recommendations.
4. Ensure that the fibers are fully distributed, without clumping.
5. During batching, keep the temperature of the UHPC below 85°F. Add ice to the mix as recommended by the UHPC manufacturer's representative, but do not exceed the allowable specified water-to-cementitious materials ratio.
6. Ensure that the measured average amplitude of the exposed aggregate finish for all precast concrete surfaces in contact with UHPC is between 1/8 inch and 3/16 inch.
7. Keep connections free of any oil, dirt, and debris.
8. Prior to UHPC placement, prewet precast concrete surfaces that will be in contact with UHPC. Continuously wet the concrete contact area with fresh water for at least 24 hours prior to the UHPC placement.

9. Remove all standing surface water just prior to UHPC placement.
10. Follow the batching sequence as described in the approved UHPC detailed work plan.
11. Fill the surface of the UHPC field joints to 1/4-inch above the surface of the adjacent concrete surface.
12. Place UHPC in accordance with the approved placement plan. Do not use internal vibrator during UHPC placement. The use of rodding of UHPC is allowed at the locations where successive pours meet. Keep UHPC at the manufacturer's recommended temperature range.
13. On short bridges, place the UHPC in a continuous operation with no cold joints. For long bridges, submit for Engineer's approval, the UHPC placement sequence, including all planned joints. Cure UHPC in accordance with the manufacturer's recommendations.
14. Ensure that the connection joints remain free from differential movement and rotation until the UHPC achieves the required compressive strength shown in the Plans.
15. Cure and cover joints until the UHPC has achieved a compressive strength of at least 10,000 psi.
16. Ensure that all lifting lug pockets and any other deck protrusions are water blast cleaned and filled with UHPC.
17. After the installation of the bridge deck joints, perform water integrity test in accordance with 349-10.2.
18. Perform grinding of the UHPC surface after UHPC achieves the required compressive strength shown in the Plans. Suspend grinding if significant fiber pullout is observed during grinding operations. Take corrective action to prevent the recurrence of the problem and such action requires the Engineer's review and approval prior to implementation.
19. Do not open the bridge to traffic until the required UHPC compressive strength defined in the Plans, has been achieved.

### **349-9 Sampling and Testing.**

**349-9.1 UHPC Quality Control Sampling and Testing:** During field demonstration of mockups and construction, perform sampling and testing of UHPC at the frequencies described in Tables 349-1 and 349-2, respectively. Perform the following quality control sampling and testing during casting of the mockup and field casting of UHPC placement:

1. Measure the flow of each batch of UHPC. The allowable flow range is between 8 to 10 inches.
2. Record UHPC flow, ambient air temperature, and mix temperature for each batch. Include the time and date, amounts of water and ice, and admixtures corresponding to the UHPC batch and LOT numbers for traceability. A LOT of UHPC is defined as 15 cubic yards or one day's production, whichever comes first.
3. As part of the as-built records, track and show the placement locations of UHPC LOTs. Submit a copy of the as-built records to the Engineer.
4. Compressive Strength Cylindrical Specimens: From every LOT, take four sets of three compressive strength test cylinders. One set will be taken at the beginning and one set at the end of the LOT. In an evenly distributed manner, take two intermediate sets from the middle portion of the LOT. Cure all sets in an environment like that of the placed UHPC. For traceability, track all sets to LOT numbers.

Table 349-1 UHPC- Sampling and Testing Frequencies During Field Demonstration of Mockup		
Material Characteristic Description	Test Method	Minimum Sampling and Testing Frequency
Flow of UHPC	ASTM C1437 (Using Modifications Described in ASTM C1856)	Required number of tests per 349-7.2 mix workability
Time of setting of UHPC	ASTM C191 (Using Modifications Described in ASTM C1856)	One test during mix design verification or field demonstration
Temperature of freshly mixed hydraulic cement concrete	ASTM C1064	One test per batch
Compressive strength of cylindrical concrete specimens	Make test specimens in accordance with ASTM C31 and test them in accordance with ASTM C39 (Using Modifications Described in ASTM C1856)	Cast five sets of 3 cylinders during field demonstration. Test them at the times shown in the Plans, including at ages of 2, 4, 7, 14, and 28 days
Chloride content	FM 5-516	One test during mix design verification or field demonstration
Mix workability	349-7.2	One test per mix design during field demonstration of mockup

Table 349-2 UHPC- Sampling and Testing Frequencies During Construction		
Material Characteristic Description	Test Method	Minimum Sampling and Testing Frequency
Flow of UHPC	ASTM C1437 (Using Modifications Described in ASTM C1856)	One test per batch
Temperature of freshly mixed hydraulic cement concrete	ASTM C1064	One test per batch
Compressive strength of cylindrical concrete specimens	Make test specimens in accordance with ASTM C31 and test them in accordance with ASTM C39 (Using Modifications Described in ASTM C1856)	Four sets of 3 cylinders per LOT of 15 CY or one day's production, whichever comes first
Chloride content	FM 5-516	One test per month of UHPC production
Water integrity test for bridge deck joints	349-10.2	One test per bridge deck

**349-9.2 UHPC Quality Control Compressive Strength Testing:** For each LOT, test the compressive strength cylinders at the times that are described below:

1. Test three cylinders prior to the removal of forms and grinding of joints to ensure that the UHPC has achieved a minimum compressive strength of 10,000 psi or the required compressive strength shown in the Plans.

2. Test three cylinders to ensure that the UHPC has achieved the required strength shown in the Plans prior to opening of the bridge to traffic.

3. Test three cylinders at 28 days to verify final strength.

4. Hold the remaining three cylinders for resolution testing, if needed.

Ensure that the tests are performed by a testing laboratory meeting the lab qualifications of 105-7. Cure the cylinders onsite in a similar environment as the UHPC joint material and ship them to the Department qualified testing laboratory for testing. Cure the 28-day test cylinders and resolution test cylinders initially in the field in accordance with ASTM C31 and ship them to the laboratory for final curing and testing.

Ensure that the Quality Control (QC) testing laboratory enters the compressive strength test results into the Department's Materials Acceptance and Certification (MAC) within 24 hours of their testing, as described in 346-9.1.

**349-9.3 UHPC Chloride Content Limits for Concrete Construction:** Perform the chloride content test at a frequency of one sample per month of UHPC production. The maximum allowable chloride content is 0.40 pounds per cubic yard.

### **349-10 Quality Assurance Program.**

**349-10.1 Verification Sampling and Testing:** The Engineer will observe the UHPC placement and take verification samples for, concrete temperature, flow, and compressive strength tests at a frequency of one sample per four LOTs.

For UHPC, the compressive strength verification samples consist of six cylinders; three cylinders for the 28-day tests and three "hold" cylinders for resolution testing, if needed.

Notify the Engineer at least 48 hours prior to the anticipated UHPC placement. Final acceptance will be based upon 28-day compressive strength. Field coring of UHPC for dispute resolution is not allowed.

The Engineer will compare UHPC QC and Verification test results in accordance with 346-9.5. The Department will proceed to the resolution procedure in accordance with 346-9.6 if the difference between the QC and Verification test results exceeds 14%.

Provide an adequate location to place acceptance specimens for initial curing prior to transport to the laboratory. Equip the curing boxes with supplemental heat or cooling as necessary to cure specimens in accordance with ASTM C31.

Remove the UHPC and replace or remediate to the satisfaction of the Engineer, if the UHPC does not meet the minimal material properties of this Section.

**349-10.2 Water Integrity Test for Bridge Deck joints:** After the bridge deck joints have been installed with UHPC and formwork has been removed, flood the entire deck with water for a minimum duration of 30 minutes. Inspect the concrete surfaces under the joint during this minimum of 30-minute period, and for a minimum of 45 minutes after the supply of water has stopped to ensure that there is no evidence of dripping water or moisture. The Engineer will verify the results of the inspections by performing an independent inspection of the concrete surfaces under the joints. The surfaces on the underside of the joint are considered watertight when they are free from any sign of moisture. If the joint system exhibits evidence of water leak at any location, take remedial measures necessary to stop further leakage. Subsequent water

integrity tests may be required subject to the same conditions as the original test per the Engineer.

**349-11 Method of Measurement.**

The quantity of UHPC to be paid for will be the Plan Quantity, in cubic yards, in place, and accepted.

**349-12 Basis of Payment.**

**349-12.1 General:** Price and payment will constitute full compensation for all work including surface preparation, supplying, mixing, transporting, volume of UHPC joint mockup, placing, finishing, curing, grinding, water integrity testing for bridge deck joints, and for furnishing all equipment, tools, labor, and incidentals required to complete the work.

No payment will be made for material used in the determination of material properties or for acceptance testing.

**349-12.2 Pay Items: Payment will be made under:**

Item No. 918-349 – Ultra High-Performance Concrete – per cubic yard.

Do Not Use Without  
CO Specs Authorization